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A COMPARISON OF 8-HOUR VS. 12-HOUR SHIFTS ON PERFORMANCE, HEALTH AND SAFETY IN A USAF AIRCRAFT MAINTENANCE SQUADRON

THESIS

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THESIS

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Abstract

This study examined the effects of converting a large USAF aircraft maintenance squadron from an 8-hour shift system to a 12-hour shift system. In 1996, the squadron converted its 24-hour operations from three 8-hour work shifts, to two 12-hour work shifts with compressed work weeks. The squadron maintained 12-hour shifts for 19 consecutive months. A comparison was made of organizational performance, worker health and safety measures before, during and after 12-hour shift implementation. Findings indicated that changing from 8- to 12-hour shifts resulted in a slight increase in aircraft Mission Capability Rates. However, this benefit appears to have come at the expense of worker health, as evidenced by a ten-fold increase in worker sick call visits to the base hospital. Additionally, the squadron expended a higher proportion of direct labor hours in support of the flying schedule. There were no significant differences in any other aircraft reliability, maintenance repair or deferred maintenance indicators. On- and off-duty accident rates were also examined. There were no significant differences noted between mean 8- and 12-hour shift accident rates. The decision to implement 12-hour shifts is one that must be made with careful consideration of the costs and benefits identified in this study.

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I. Introduction

Background

Flying safety depends on the proper conduct of three sets of activities: aircraft design, operations, and maintenance (Maddox, et al., 1998). A recent USAF class-A mishap involving maintenance of an F-15 is a good example of how all three of these activities may contribute to a disaster. Maintenance technicians improperly connected the aircraft's flight control rods. During an attempted takeoff, the aircraft crashed, killing the pilot. Fatigue and other human factors play an integral role in maintenance support operations as well. Palmer, et al., found of 96 Air Force fatigue-related class-A mishaps for the period 1972-1995, 19 (19.8%) were identified as "logistics" mishaps (1996:5).

Broadly defined, shiftwork can be thought of as a work routine other than a standard (8-hour) workday (Monk, 1989). Most shiftwork research in the military has been focused on aircrew, tank crews, and soldiers (Palmer, et al., 1996 and Haslam, 1982). Alluisi and Morgan called the study of performance measures and shiftwork a "major research gap" (1982:176). Baker and Morisseau assert that research and information dissemination in the area of operator fatigue and performance has not kept pace with the utilization of shiftwork (1992:117). More specifically, in *Human Factors*

Guide for Aviation Maintenance, Maddox, et al., found no published reports dealing with the effects of shiftwork on aircraft maintenance workers and performance (1998).

Recently, in an effort to cope with manpower reductions and keep pace with a busy flying schedule, one Air Force aircraft maintenance organization implemented a 12-hour shift schedule for a period of more than 19 months. During this time, a study was conducted to examine the impact of 12-hour shifts on maintainer morale, motivation, health and safety (Overland, 1997). Yet to be examined are the effects of this 12-hour shift implementation on organizational performance, worker health and safety.

Terms Defined

Shiftwork research is a multi-faceted field. Many situational factors exist which can lead one to various conclusions about the affects of shiftwork. On the surface, these conclusions may even seem to be contradictory. However, close examination of the many factors involved will result in focused conclusions that are relevant to the particular shiftwork routine under study. For this reason, definition of the following terms as they apply to this study is required.

Shiftwork. The schedule implemented by the organization under study -- two 12-hour shifts provided 24-hour coverage with a 2-day on, 3-day off, 3-day on, 2-day off schedule. Over a six-month period, a worker would be on duty an average of 3.54 days, (42.46 hours) per 7-day period. The additional hours worked have the net effect of adding the equivalent of 47 workers to the unit over a six-month period. (These

calculations assume continuous availability for work -- no absences for leave, illness or temporary duty, and an average squadron manning level of 771 workers.)

8-hour shifts. Three work shifts per 24-hour day, each lasting approximately eight hours -- a traditional day shift, swing shift and grave shift routine.

12-hour shifts. Two work shifts per 24-hour day, each lasting 12 hours.

Performance. A measure of how well a task is accomplished. Poorer performance includes lower productivity -- better performance includes higher productivity. In this study, performance is measured using certain Logistics Readiness Indicators, which are described in the next chapter.

Day shift. A 12-hour work shift that begins at 0700 hours and ends at 1900 hours the same day.

Night shift. A 12-hour work shift that begins at 1900 hours and ends at 0700 hours the following calendar day.

Rotating shifts. Any shiftwork schedule that routinely requires workers to change either their work shift or their scheduled duty days.

Fixed shifts. Non-rotating shifts. A stable, consistent work schedule with a repeating day and shift pattern. The shift routine defined for this study is a fixed shift.

Compressed shifts. Working longer shifts each day, but fewer days each week.

Outcomes of Interest

The outcomes of interest in this study are organizational performance, worker health and safety. The number of sick call visits to the base hospital is used to measure

health of squadron personnel (Lees and Laundry, 1989). Worker safety is measured by the number of on- and off-duty accidents reported to the wing safety office (Duchon and Smith, 1993). Because there are a wide variety of performance outcomes available, measuring organizational performance as an outcome of shiftwork requires greater discrimination.

Organizational performance generally refers to measures of productivity or mission success, and implies efficiency and effectiveness. Each organization has its own unique mission and goals that shape the definition of organizational performance. Useful measures of organizational performance explain the degree to which the organization's mission is being accomplished (Tuttle, 1980). A major goal of an aircraft maintenance squadron is to generate reliable, mission-capable aircraft in sufficient numbers to meet the operational schedule. In this study, the focus is on mission accomplishment as indicated by certain Logistics Readiness Indicators (LRI) -- a family of performance measures similar to those suggested by Tuttle (1980:30). These LRI have been selected based on what they are designed to measure (Pritchard et al., 1988). Specifically, they reflect aircraft mission capability and reliability rates, and worker productivity in the form of awaiting maintenance actions and 12-Hour Fix Rates. These indicators are discussed further in Chapter II.

Problem Statement

The effects of shiftwork and the role of human factors in aircraft maintenance and operations are issues of considerable interest in the Air Force (O'Connor, et al., 1984;

Palmer, et al., 1996; Crew Systems Directorate, 1996). Dwindling budgets and manpower levels, aging aircraft, and increasing operations tempo all place additional workloads on aircraft maintainers. Shiftwork is one way the Air Force attempts to meet these challenges. By increasing manpower availability, shiftwork generally increases production over short periods, but may also have mixed effects on performance, health, and safety (Folkard and Monk, 1979). The decision whether or not to utilize shiftwork may impact mission success in positive and negative ways. This decision should be made from the best-informed position feasible. Leaders should weigh the costs and benefits, and decide the best way to meet operational requirements.

Research Objectives

This study focuses primarily on examining the differences that occurred -- or failed to occur -- in the outcomes of interest, as a result of implementing 12-hour shifts. Specifically, this study will attempt to answer the following research questions:

- Does the implementation of a fixed, 12-hour shift routine produce organizational performance results that are better than the 8-hour shift routine, as indicated by various Logistics Readiness Indicators? If so, how large is the difference?

- Does the implementation of a fixed, 12-hour shift routine produce on- and off-duty accident rates worse than the 8-hour shift routine, as indicated by reported accidents? If so, how large is the difference?

- Does the implementation of a fixed, 12-hour shift routine produce health problems that are worse than the 8-hour shift routine, as indicated by the rate of sick call visits per person? If so, how large is the difference?

An additional goal of this study is to examine the differences produced by the return to 8-hour shifts from 12-hour shifts. This additional examination may be useful in

providing insight to the effects of shiftwork on the outcome variables. For example, many workers tend to favor compressed shiftwork because they have larger blocks of time off. Returning to the five day, 8-hour shift routine, especially after having made the adjustment to 12-hour shifts, may be accompanied by decreased worker performance due to a lower level of worker satisfaction (Budnick, et al., 1994).

Shiftwork's impact on fatigue and stress may lead to reduced performance, and/or health and safety problems among the work force (Folkard and Monk, 1979). Additionally, mishaps in aircraft maintenance and/or flying operations may result. We can not afford to let these issues go unexamined. Aircraft maintenance is a business where taking one wrong step off a maintenance stand, or failing to deactivate a flight control before working on it -- human factors-type mistakes -- can result in severe injury or death. Shiftwork brings with it many tradeoffs in the areas of organizational performance, health and safety (Monk, 1989). Identifying these tradeoffs as they apply to the Air Force, and examining how they might impact mission effectiveness, is the purpose of this study.

II. Literature Review

Why Shiftwork?

The decision whether or not to utilize 12-hour shifts in a maintenance organization brings with it tradeoffs which must be considered carefully. Some of these tradeoffs are fiscal and some are performance-related. Others are subtle and may go unnoticed. There is considerable interest among Air Force leadership in the effective utilization of shiftwork, and the effects on performance, health and safety. (Crew Systems Directorate, 1996).

Military operations frequently involve around-the-clock operations. In fact, even when an operational wing is involved in daytime-only flying operations, much of the required aircraft maintenance can only be done at night. Shiftwork allows military organizations to respond quickly to surges and meet the demands of rapidly changing missions. Additionally, shiftwork can be used to overcome short-term manpower shortages by allowing units to operate fully manned two-shift (12-hour) operations, as opposed to thinly manned three-shift (8-hour) operations.

These benefits do not come without their costs. Twelve-hour shifts may result in increased worker health problems and, in some cases, increased accident rates (Folkard and Monk, 1979; Duchon and Smith, 1993). Furthermore, shiftwork may increase conflict between worker/family roles, thus increasing worker stress (Monk and Folkard, 1992). Stress and fatigue can lead to poor quality work that in turn, degrades mission effectiveness. Improper maintenance may go undetected until such a time when it causes

a noticeable problem. The work must be redone, thus adding additional workload to the unit's mission. These detriments may mitigate some of the benefits mentioned above.

An increasing number of civilian organizations have implemented shiftwork in their operations. Advances in technology and global competition have resulted in the need for continuous services and operations (Monk and Folkard, 1992, 2-3). Extensive studies of shiftwork in the commercial sector may provide useful information for military applications as well. Some of the literature from these studies is reviewed below.

Shiftwork's Effect on Performance

Many organizations attempt to increase performance by changing from three 8-hour shifts to two 12-hour shifts (Pierce and Dunham, 1992:1086). While it is commonly perceived that 12-hour shifts are more productive, care must be taken not to confuse performance with productivity. Productivity is an essential factor in determining performance. However, few managers would accept increased production at the expense of quality work.

Researchers have found performance is reduced at night. In a 12-hour shift operation, theoretically half of the workload is done at night. In an aircraft maintenance environment, the night shift does much of the workload -- especially corrective maintenance. Studies have shown that shiftwork is linked to decrements in performance, even after the shift routine was in place for more than three years (Rosa, 1991:115). Alluisi and Morgan cite several studies that conclude night shift performance is inferior to that of day shift (1982:176-177). Lewis and Swaim evaluated performance measures

for 8- and 12-hour shifts, and found no significant increase in performance between the two shift routines (1986:886-887).

A comprehensive analysis of the factors that influence the relationship between shiftwork and performance is key to understanding the effects of shiftwork. Performance is believed to depend primarily upon three factors: (1) task demand, (2) type of shiftwork system, and (3) individual differences between shift workers and their ability to adjust to shiftwork (Folkard and Monk, 1979:490).

Tasks that demand high memory load or complex cognitive skills are considered to be poor choices for night shiftwork (Folkard and Monk 1979:485-486; Duchon and Smith, 1993:44-45). Worker responsiveness, alertness, short-term memory and cognitive abilities are all degraded (Czeisler, 1993:128-129; Folkard, 1990:95). Aircraft maintenance frequently requires complex fault isolation tasks. It is not unusual for workers, after having spent several hours troubleshooting, to reach what seems to be an impasse -- only to discover later on -- that the solution was rather straightforward and had been overlooked by a tired crew.

The type of shift system implemented also plays an important role in performance. For example, a rotating shift tends to be more disruptive to workers than a fixed shift. Workers do not have a chance to adapt to their work routine. Compared to rotating shifts, fixed shifts have been linked to higher performance in manufacturing (Liou and Wang, 1991).

Finally, individual differences -- differences in circadian rhythm, age, gender, physical fitness, and flexibility in sleeping habits -- have been shown to be related to

performance (Harma, 1993:104-106). When these factors are controlled for, all humans still possess similar performance limitations. These limitations are why people make more errors during night shifts, particularly on complex tasks (Miller and Swain, 1987:224).

Given the shiftwork routine implemented by the aircraft maintenance squadron, the time that a significant portion of the workload is done and the nature of the tasks involved, 12-hour shifts are expected to result in decreased performance indicators. As worker fatigue and stress increase, performance is expected to decline.

Shiftwork's Effect on Health

There is strong evidence that shiftwork has an adverse effect on the health of a work force. The results of numerous studies support this claim. Budnick, et al., reported that shift workers have an increased risk of stress-related illnesses, stomach problems and overall poor health (1994:1295). Sparks, et al., conducted a meta-analysis of studies relating health to length of work shifts. They reported a relationship between the length of the work shift (hours per day) and ill health. As work shifts lengthened, health complaints increased (1997:401-402).

It appears that the primary health risk factors of shiftwork are sleep disruption and altered eating patterns. Fatigue increases stress levels, which may lead to increased illness. Additionally, altered eating patterns contribute to gastrointestinal complaints (La Dou, 1982:526-527). The effects of shiftwork on health vary from one worker to

another. Age, individual differences, the nature of the work and shift type, are important factors that influence worker health (Laundry and Lees: 1991:905-910).

The length of the work shift is linked to poor life style habits. Longer work hours are associated with over-eating, smoking, increased alcohol consumption and lack of exercise (Gordon, et al., 1986). These poor life style habits are believed to be at least partially responsible for some health-related complaints. Scott and La Dou found shift workers reported more digestive problems, chest pain, stress, nervousness, colds and fatigue (1990).

Finally, Spelten, et al., found that shiftworkers have gradually become accustomed to shift-related problems and tend to underestimate them (1993:307). This may present a future problem for shiftworkers and researchers alike. As workers become accustomed to these health problems, their health may deteriorate further if neglected. Additionally, the ability of researchers to accurately measure health effects may be hindered by less reliable data.

In this study, it is expected that 12-hour shifts will have an adverse effect on worker health. This is mainly because of the increased number of hours worked by both day and night shifts and the associated increase in stress and fatigue among the workers.

Shiftwork's Effect on Safety

The effect of 12-hour shifts on worker safety has not been studied in great detail. However, what research that has been done in this area has produced interesting (and unexpected) results. Laundry and Lees reported a significant decrease in on-the-job

injuries during 12-hour shifts (1987:165). In a later study that covered ten-year periods both before and after the change to 12-hour shifts, they again found on-duty accidents were reduced during the 12-hour shift routine. They attributed this unexpected decrease to the type of industry under study. It was moderately automated and the researchers believed that 12-hour shifts, in that environment, did not result in greater physical overload or increased fatigue. In occupations requiring a different level of manual or cognitive dexterity, fatigue may develop more quickly during 12-hour shifts and result in an increased mishap rate (Laundry and Lees, 1991:903-906).

Research of off-duty accidents has been less conclusive (La Dou, 1982; Laundry and Lees, 1991). This has been attributed to less accurate reporting of off-duty accidents. Researchers believe that many off-duty mishaps go unreported unless they result in sufficient injury that interferes with the worker's ability to report for work (Laundry and Lees, 1991: 905). In one study of accidents among shiftworkers, Monk, et al., noted the number of shift workers that had an automobile accident or a near miss on the drive home from work was 20% higher for night shift workers than for those working the day shift (1996:20). These accidents were attributed to fatigue. Budnick, et al., also compared day shift workers to night shift workers. They found night shift workers experienced more mishaps on the job and more motor vehicle accidents during their drive home from work (1994:1298). Laundry and Lees believed shiftwork was related to increased off-duty accidents. However, their results were not statistically significant, and they concluded that 12-hour shifts did not result in a significant increase in accident rates (1991:903).

Aircraft maintenance operations are closely related to other industrial operations, though less automation exists. Twelve-hour shifts are expected to increase on-duty accident rates.

Increased blocks of worker leisure time are one reason to suspect off-duty accident rates will increase during 12-hour shifts, especially if the work week is compressed, as it is in this study (Laundry and Lees, 1991). Off-duty accident rates are also expected to increase during 12-hour shifts.

Effects: A Closer Look

Effect on Circadian Rhythms, Sleep and Fatigue. Shiftwork exposes more than twenty million American workers to major disruptions in physiological and social aspects of their lives. The two primary physiological areas are circadian rhythmicity and sleep (Rosekind, et al., 1994:327). Circadian rhythms can be thought of as the body's internal biological clock that programs the body to behave differently at different times of the day. These rhythms effect how well we sleep, think, remember, and perform. Shiftwork conflicts with our circadian rhythms, and can contribute to degradation of performance (Graeber, 1988:307-311). This conflict is not easily overcome. It may take several days for the body to make the adjustment. Monk suggests the adjustment is never completely made during shiftwork routines (1989:111).

Within a limited range, our internal clocks can be resynchronized by entrainment of environmental cues called "zeitgebers" (time-givers) (Folkard and Monk, 1979:484; Graeber, 1988:310-311). Sunrise, sunset, habitual patterns of work, social interaction,

awareness of clock time, rest, sleep, and routine mealtimes are all examples of zeitgebers (Hockey, 1986:44-24; La Dou, 1982:525-526).

Liou and Wang found that circadian desynchronization occurs after just two days off from shiftwork routines (1991:656). This desynchronization necessitates another adjustment period at the start of the next work week. Thus, the worker's internal body clock remains in a near-constant state of fluctuation. The degree to which this desynchronization occurs, and the tolerance one has toward shiftwork, varies among individuals (Vidacek, et al., 1993:122).

Shiftwork schedules are associated with increased levels of fatigue (Budnick, et al, 1994:1295). Fatigue can cause people to overlook what usually appear to be the most obvious of details -- from landing an aircraft with the landing gear up -- to forgetting which runway the aircrew were cleared to land the aircraft on (Graeber, 1988:306). Errors caused by fatigue may also occur on the ground. Aircraft maintenance requires the use of many types of powered support equipment that, if improperly used, can cause damage to equipment and personal injury.

Night shift workers average two to three hours less sleep per day than day shift workers (La Dou, 1982:526). Obtaining even one hour less sleep than required can affect waking levels of sleepiness (Rosekind, et al., 1994:327). Tepas and Monk carry this assertion further, pointing out that work shifts associated with off-duty time sleep deprivation should be expected to produce increased worker fatigue during duty hours (1987:831). A more recent study estimated that 75% of those working at night experience sleepiness every night. Twenty percent of these workers actually fall asleep

on their work shift (Akerstedt, 1992:63-64). Finally, time does not seem to help workers adapt to shiftwork. Rosa discovered that, even after 3.5 years of 12-hour night shifts, workers continued to experience 1-3 hours less sleep per day. Fatigue and alertness measures remained relatively unchanged from earlier measurements conducted after just seven months on 12-hour shifts (1991:107).

Circadian rhythm desynchronization as a result of shiftwork has been found to have an adverse effect on sleep quality and quantity, fatigue levels, job performance and health and safety (Ferrer, et al., 1995:577; Folkard, 1990:551; Hockey, 1986:44-28).

Work/Home Role Conflict. Shiftwork frequently leads to increased stress and neglect of satisfying one's domestic responsibilities. This is due to the work/home role conflict created by longer working hours (Gordon et al., 1986:1227). In an attempt to make up for more time spent at work, shift workers may give undue attention to these responsibilities, thus taking even more time from the family and creating additional strain on relationships (Monk and Folkard, 1992:21-22). One possible solution to this conflict is compressed shiftwork -- extending the length of the day, thereby reducing the number of days worked per week. This allows more time off between shifts, which gives the opportunity to satisfy one's domestic roles and affords time for leisure activities as well. Managing shiftwork in such a way that would reduce the work/home conflict may reduce some of the stress created by shiftwork (Cunningham, 1989:231-232).

Outcome Variables Defined

This section lists and describes the measurements that represent the outcome variables of interest for this study.

Logistics Readiness Indicators. Tuttle (1980) suggests that what constitutes accurate organizational performance measures depends on both the mission involved and the perspective from which management interest is generated. Organizational performance indicators must be chosen on the basis of their ability to help us learn what it is we desire to learn (Pritchard and Roth, 1991:341). Because of the interdependencies in the work performed, complex measures of performance may be required to accurately measure organizational performance (Pritchard et al., 1989: 339). These interdependencies also explain in part, why there tends to be little consensus on a definition of organizational performance. In this study, the objective is to measure the effects of 12-hour shifts as closely as possible, while simultaneously avoiding outcome variables that may be influenced by confounding factors for which we can not control. Specific rationale for selection and the expected outcomes during 12-hour shifts for each variable are presented with each indicator description.

Mission Capable (MC) Rate. This indicator is the number of possessed hours that aircraft were reported as either Fully or Partially Mission Capable (FMC or PMC) divided by the total number of hours the aircraft was possessed by the using organization. The MC Rate is representative of the serviceability of the aircraft fleet. Inefficient performance has a negative effect on this measurement, because it reduces the number of hours the aircraft are either FMC or PMC. The effects of 12-hour shifts may include

higher performance rates because of increased personnel resources (Monk, et al., 1996). However, as time passes, performance rates are expected to decline as fatigue and stress erode performance (Klein, 1988).

Direct Labor-Hours per Flying Hour. This measurement indicates how many direct labor hours were expended per flying hour. Direct labor hours are those hours expended in support of repair operations, and do not include indirect labor hours -- training, administrative tasks, non-production related details or routine aircraft servicing task hours -- fuel, hydraulic, oxygen servicing, etc. Therefore, this indicator includes a higher proportion of tasks that require a higher cognitive level of work. Examples of this type of work include fault isolation and operational checkout. Shiftwork is expected to reduce the number of direct labor hours per flying hour, mainly due to reduced shift turnover (Lewis and Swaim, 1986:888). Two 12-hour shifts per 24-hour day results in not having to stop work and turn the job over to the next shift as frequently as is necessary under a three 8-hour shift routine.

Awaiting Maintenance (AWM) Discrepancies. This measures the average number of non-grounding discrepancies per aircraft that have been deferred from immediate work. Such deferrals occur because the maintenance unit needs more time (including aircraft downtime) and/or personnel resources, to correct the discrepancy. Other resources that may be required (i.e. parts) are already on hand. The increased manpower availability of 12-hour shifts is expected to reduce the number of AWM discrepancies.

Home Station (HS) Reliability. Home Station Reliability is the percent of time (in number of events) aircraft are ready to fly (mission capable) at the time the aircrew shows

or was scheduled to show. This indicator measures how often the aircraft was ready on time, when compared to the number of times the organization was required to make the aircraft ready. Inefficient performance may not be evident from this measurement. Whether or not the aircraft is ready eight hours or eight minutes before the required time, the aircraft is considered ready. Early delivery has no impact on Home Station Reliability -- either the aircraft is ready or it is not. This measurement is important because it is a production-type (sortie generation) outcome. Twelve-hour shifts should result in increased Home Station Reliability, because on average, more personnel resources will be available to prepare aircraft for flight.

Twelve Hour Fix (12-Hr Fix) Rate. This measurement is indicative of the unit's ability to return an aircraft to mission capable status after the aircraft returns from a previous sortie in non-mission capable (NMC) status. It is the percent of aircraft returning from a mission as NMC that are returned to mission-capable status within 12 hours of landing. Fix rates are indicative of a unit's ability to repair aircraft effectively and efficiently. This measurement is useful because it can yield insight to the unit's ability to both identify and repair a discrepancy whose cause is initially undetermined. Because these tasks generally include some fault isolation skills, they tend to require higher cognitive levels of work. As previously mentioned, the effects of shiftwork may be particularly evident in these types of tasks. The 12-Hour Fix Rate is expected to decline during 12-hour shifts. This is mainly due to increased fatigue and stress in the work force, which may lead to less efficient fault isolation and/or repair actions.

Health and Safety Indicators. The variables chosen to examine work force health and safety are similar to those examined in several other studies of the effects of shiftwork. Lees and Laundry (1989) and Scott and La Dou (1990) used self-reported health complaints to examine worker health. Duchon and Smith, (1993) and Laundry and Lees (1991) examined on- and off-duty accident rates as an indicator of worker safety.

Sick Call Rate. This indicator was obtained from the base hospital, and reflects the number of same-day sick call appointments per person. Shiftwork is frequently associated with higher rates of self-reported health problems. The sick call rate is expected to rise during 12-hour shifts.

On- and Off-duty Accidents. These indicators were obtained from the base safety organization and reflect the number of accidents reported among personnel. Shiftwork has a negative effect on this indicator, particularly during the night shift. However, several studies have been inconclusive on this issue, especially over long time periods. In this study, the number of on-duty accidents is expected to rise during 12-hour shifts.

Workload, Manpower and Experience Levels

The outcome variables are not solely influenced by a finite set of factors. As discussed above, the objective is to accurately measure the outcome variables that yield the best insight to the effects of 12-hour shifts. However, precise and completely unambiguous measurement is unlikely (Cooper and Emory, 1995:147). Therefore, it is necessary to allow for the effects of various factors which may influence the variables in a way that would challenge the validity of the measurement (Cooper and Emory,

1995:149). These factors should also be measured (as previously discussed) in the same manner suggested by Pritchard (1989) and Tuttle (1980).

The outcome variables are also influenced by workload and manning levels. These factors must be controlled for in a way that will allow for their influence on the performance indicators. The methods by which the effects of 12-hour shifts are measured and associated factors are controlled for, are discussed in the next chapter.

III. Method

Data Sources

Concomitant Variables. Concomitant variables represent extraneous factors that may also have an influence on the outcome variables. Controlling for these covariates when comparing the period means is necessary to account for their influence on the dependent and independent variables (Kachigan, 1986:331). In effect, this method tests an alternate explanation for the relationships among the variables of interest. In this study, the influence of several concomitant variables needed to be tested. They are listed and described below.

Sorties. A measure of squadron workload, it is the number of flights launched from the home station. Sortie generation is the squadron's primary indicator of maintenance production (output). Sorties directly affect the maintenance requirements of aircraft systems.

Hours Flown. This is sum of all flying hours during the period. Hours Flown directly impacts equipment serviceability. Requirements for many maintenance tasks are based on this indicator -- especially engine work, structural inspections and other critical maintenance actions. Increased flying time generally leads to increased maintenance requirements. The number of hours flown provides a measure of workload, which differs from the number of sorties. Sortie duration may be long or short. Flying times can vary depending on the destination, weather, cargo load, and mission profile.

Direct Labor Hours. This data includes only those hours spent in direct support of the weapon system. Indirect labor activities such as aircraft servicing, leave, TDY, illness, training and administrative time are not included in this variable.

Work Force Skill Level. This variable was computed from skill level data provided by the squadron mobility and manning office. It is the sum of five- and seven-level workers, divided by the sum of three-, five- and seven-level workers. This variable represents both manning level and experience of the work force. Three-level workers are in upgrade training, and usually do not perform unsupervised maintenance. Five-level workers usually supervise the three-level workers, and also perform some unsupervised maintenance. However, seven-level workers must inspect some of the tasks performed by the three- and five-level workers. Seven-level workers may supervise three- and/or five-level workers. Additionally, they perform many of the more complex maintenance tasks. Five- and seven-level workers make up the bulk of the "fully-qualified" work force, and account for most of the squadron's productive maintenance.

Manpower. This figure indicates the manning level of the squadron. It is a measure of assigned personnel and represents, in terms of personnel strength, the squadron's personnel resources assigned to accomplish the workload. In this study, it is the average sum of the three-, five- and seven-level workers.

Sorties, Hours Flown and Direct Labor Hours were obtained from the analysis section that provided the Logistics Readiness Indicator data. Sorties and Hours Flown represent measures of workload. Direct Labor Hours is a measure of effort expended in support of workload. Manpower and Work Force Skill Level data were obtained from

squadron mobility/manning records. This work force data is typically used for personnel management, deployment planning, and training management.

Logistics Readiness Indicators

The performance indicators and concomitant variable data for this study were chosen from a larger set of Logistics Readiness Indicators. These data are maintained and used by the Logistics Maintenance Data Systems Analysis section of the Logistics Group to assist in managing aircraft maintenance operations. Each performance indicator data point represents an entire month's data (see appendices). The indicators selected for use in this study measure different aspects of organizational performance. As outlined in the previous chapter, they are: Mission Capable Rate, Direct Labor Hours per Flying Hour, Average Awaiting Maintenance Discrepancies, Home Station Reliability, and 12-Hour Fix Rate. These indicators are described in AMC Pamphlet 21-102, "Unit Health of the Force and Maintenance Analysis Guide," which defines the methods and formulae used by Air Mobility Command analysts. Typical uses of data from Air Force reporting systems of this type include Health of Forces reports and statistical analyses for congressional committees, the Office of Management and Budget, and the Department of Defense (AFI 21-103, 1997:8).

Health and Safety Indicators

There is considerable evidence that working on 12-hour shifts affects worker health and safety (Duchon and Smith, 1992:41; Laundry and Lees, 1991:904). The health

measure used in this study is the number of visits per person per month to the base hospital for "sick call." The hospital visit rate was computed by dividing the total number of sick call visits by the number of assigned personnel. The data were obtained from hospital appointment records.

The on-duty accident data was obtained from the wing safety office. This data was compiled from reported mishaps that resulted in personal injury and/or damage to equipment during duty hours. The off-duty accident data was obtained from squadron safety records. This data includes mishaps at home, during sporting or leisure activities, or other non-work related accidents. Both accident rates were computed by dividing the number of accidents by the number of assigned personnel.

Observation Periods

Data from three time periods were compared to measure possible changes in organizational performance, worker health and safety. Each time period was five months long, and includes approximately 150 days of performance, health and safety data. The periods were chosen to reflect as closely as possible, routine, day-to-day unit operations under one of three conditions: a normal 8-hour shift schedule before any schedule changes, a 12-hour shift schedule and an 8-hour shift schedule after the 12-hour operation ended. The procedures used to select each time period are described below. They were intended to help remove the effects of extraneous factors, which might make it difficult to obtain reliable results.

The three time periods all begin on 1 October and end the last day of February. Beginning at the start of a fiscal year reduces the likelihood that a flying schedule different from that of routine operations would be in place. The addition or deletion of sorties for fiscal reasons is less likely in October than in August or September. Selection of homogenous time periods avoids seasonal effects in the data that may be caused by different weather conditions or changes in the work force caused by the reassignment of military personnel -- which occurs primarily between May and August each year. (Campbell and Stanley, 1963:39). For example, aircraft maintenance under winter conditions is quite different from aircraft maintenance under summer conditions. Lastly, if different months were used in different time periods, the length of the work shifts in terms of daylight hours would be different. This would mean that the work force as a whole, would have varying circadian synchronization cycles between work periods, which could influence the data.

Period One, the pre-treatment period, includes October, 1994 through February, 1995. During this time, squadron maintenance personnel worked a fixed three-shift, five-day, 8-hour shift routine. During this period, no plans were in existence to change to 12-hour shifts. Thus, this period represents a fairly stable operational period, suitable for use as a baseline period against which two subsequent time periods will be compared.

Period Two, chosen to represent the 12-hour shift treatment time, runs from October, 1996 through February, 1997. During this period, nearly all maintenance technicians were working 12-hour shifts. They had been on 12-hour shifts for at least four months, which should be long enough to adapt to the 12-hour shift schedule (Monk,

1986:553). The squadron incrementally phased in the 12-hour shift routine, first moving one-half of the workers to 12-hour shifts in February, 1996. (The October 1995 to February 1996 period could not be used for analysis, because the initial implementation of 12-hour shifts occurred in this period. Additionally because the 12-hour shift implementation had been discussed and planned for some time, uncertainty and apprehension in the work force might have had a confounding effect on performance if this period had been used.) The majority of the remainder of the squadron moved to 12-hour shifts five months later. A small group of supervisors remained on 8-hour shifts.

Period Three represents a return to the same (8-hour) shift routine as Period One. This post-treatment period begins less than one month after the end of the 12-hour shift period. Ideally, an examination of the changes experienced after returning to 8-hour shifts would come from a time period equidistant from the treatment period (Cooper and Emory, 1995:358). For example, the period from October, 1998 through February, 1999 might help control for maturation of the work force. This may give more accurate insight as to whether or not the outcome variables returned to the same levels as observed in the pre-treatment period. However, due to time constraints, it was not possible to wait another year to collect the data. Nonetheless, the examination of this additional time period is warranted, and may provide useful information.

Data Analysis

Preliminary Analysis. All of the outcome variables except AWM discrepancies are proportional data. It would have been possible to analyze the differences between the

period means by treating them as results of independent binomial experiments (McClave and Benson, 1994:433). With this method, each period mean would represent data from that period's total number of sorties flown. Differences in the mean values would either support or fail to support hypotheses about the effects of shiftwork. A mean number of 2,305 sorties were flown per period observed. This is a sufficiently high number of observations for this type of statistical analysis. However, it is not possible to control for the effects of concomitant variables with this method. Without the ability to remove such effects, it is possible that statistically significant results would be found that, in truth, were effects of concomitant variables. It was decided to forego this method in favor of Analysis of Variance, which does consider the influence of concomitant variables and is more accurate and conservative.

Test for Normality of Data. Normal Q-Q Plots were produced for all of the concomitant and outcome variables. The residuals plotted in a linear fashion. No extreme departures from normality were noted. The analysis gave no reason to believe problems in the distribution of the data would lead to incorrect conclusions.

Bartlett's Test of Homogeneity of Variances. The Bartlett's test checks to see whether or not the variances are equal between-period means. When sample sizes are equal, as in this study, the F test is only slightly affected by unequal variances (Neter et al., 1990:624). Nonetheless, Bartlett's Test of Homogeneity of Variances was conducted to examine between period differences in variance.

Analysis of Variance/Covariance. To compare the three period means, Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) were used in this study.

The overall F test used in these methods is robust against departures from normality in the data, and ANOVA methods produce good results when departures from normality are not extreme (Neter et al., 1990:623).

Bonferroni Test for Multiple Comparisons. ANOVA and ANCOVA simply indicate whether or not a difference between the period means exists. When comparing multiple periods, it must be determined which periods are different, and how much they differ. However, use of multiple comparisons increases the risk of experiment-wise error, possibly leading to a higher proportion of significant results than is warranted. This would lead to overstating the impact of shiftwork on the outcome variables -- possibly leading to unnecessary changes in policy or procedures. The Bonferroni Test for Multiple Comparisons is a conservative procedure, and was used to determine which period means differed (McClave and Benson, 1994:867).

IV. Results and Analysis

Comparisons/Analysis Model

To determine if there was a significant difference between their period means, an ANOVA was performed on each of the concomitant variables. Controlling for concomitant variables that do not significantly differ between periods would add little or no explanatory information to the experiment. Of the five concomitant variables tested, mean Work Force Skill Level ($p < 0.01$), Manpower, ($p < 0.01$) and Direct Labor Hours ($p < 0.01$) were significantly different. There were no significant differences between the mean number of Sorties or Hours Flown. A Bartlett's test indicated equal variances for Work Force Skill Level ($p < 0.03$) and Manpower ($p < 0.01$), and unequal variances for Direct Labor Hours ($p < 0.33$). As a result, Direct Labor Hours was not considered a reliable concomitant variable, mainly because of its composition. Measuring only direct labor hours can be misleading, because aircraft servicing, which makes up a large part of sortie generation, is not included in the Direct Labor Hour statistic. Work Force Skill Level and Manpower were highly related, but Work Force Skill Level seemed a better indicator because it includes worker experience and manpower levels (Folkard and Monk, 1979). The final model selected to examine the outcome was a one-way ANCOVA design with a single covariate -- Work Force Skill Level. The influence of the declining manpower level is controlled for in the Health and Safety Indicators by computing rates

for the respective indicator. The number of occurrences (accidents or hospital visits) was divided by Manpower.

Concomitant Variables

Table 1 shows the ANOVA results for comparing the differences between period means of each of the concomitant variables. Of the five variables tested, three were found to have different mean values between periods. Manpower shows a significant decline between all three periods. Direct labor hours are lower in Period Three than in Periods One and Two. Work Force Skill Level was highest in Period Two, with approximately 75% of the work force consisting of five- and seven-level workers.

Table 1. Comparison of Concomitant Variables

	Monthly Means				
Concomitant Variable	Period 1 8-Hr Shift	Period 2 12-Hr Shift	Period 3 8-HrShift	Difference Between Means	Periods Different
Manning Level	935	709	670	p < .00*	all
Work Force Skill Level ¥	65%	75%	72%	p < .00*	all
Direct Labor Hours	42,336	41,992	28,328	p < .00*	3 from 1, 2
Sorties	522	419	442	non-significant	na
Hours Flown	2,005	1,797	2,036	non-significant	na

Note: * Indicates differences are statistically significant, p < .05
¥ Percent of work force that are 5- or 7-level workers

Sorties and Hours Flown. The mean number of sorties and hours flown per month was not significantly different between the three periods observed. While Period One shows a slightly higher number of sorties, they were of a shorter duration during this period than either Period Two or Period Three. Both Sorties and Hours Flown indicate that the squadron's workload, in terms of sortie generation, remained relatively constant throughout all three periods.

Manpower. There is strong evidence that the manning level (manpower) declined ($p < .01$) steadily over all three periods. This decline was mainly due to force reductions brought about by downsizing throughout the Air Force. The reduced manpower level has a significant impact on the squadron's accident and sick call rates. It was necessary to account for this influence using the procedures discussed previously.

Direct Labor Hours. The mean number of direct labor hours expended per month was significantly lower in Period Three than in Period One or Period Two. This figure appears to be abnormally low considering a relatively unchanged workload. However, this period began almost immediately after the return to 8-hour shifts. It is likely that during the months that followed the 12-hour shifts, the work force got "caught up" in taking care of indirect labor activities that perhaps were deferred during the 12-hour shift period. Examples of these types of activities are training, administrative tasks, non-production related duties, and leave. Lastly, it is also possible that the nature of the workload simply shifted from direct labor to indirect labor maintenance (e.g. servicing).

Work Force Skill Level. Work force composition changed between all three periods. The mean skill level ratio was significantly different between all three periods ($p < .01$). During Period One, approximately 65% of the squadron's work force consisted of five- and seven-level workers. For quite some time, the squadron had been losing experienced workers as a result of work force reductions and attrition. This situation appears to have eased somewhat during Period Two, when the work force skill level climbed to 75%. In Period Three, this figure declined slightly to 72%. This data indicates that the work force was considerably more experienced during the 12-hour shift period than the preceding 8-hour shift period. Such a condition can reasonably be expected to have an influence on the performance indicators (Folkard and Monk, 1979). Controlling for work force skill level in this way not only takes into account worker experience, but also includes the number of personnel available to accomplish the workload. Removing the effects of the changing work force yields a clearer picture of the effects of 12-hour shifts (Kachigan, 1986:331).

Logistics Readiness Indicators

Table 2 shows the ANCOVA results for comparing the differences between period means of each of the Logistics Readiness Indicators. The ANCOVA controlled for the effect of Work Force Skill Level on these indicators. Mean MC Rates between all three periods were significantly different. A 1.30% increase in the mean MC Rate was observed during 12-hour shifts, followed by a 3.76% decrease during the post 12-hour shift period. Additionally, the MC Rate for Period Three was 2.46% lower than the pre-

12-hour shift period. The mean number of labor hours expended per flying hour increased by 1.46 labor hours per flying hour in the 12-hour shift period. This was followed by a decline of 9.14 labor hours per flying hour in Period Three. There were no other significant differences between performance indicator means.

Table 2. Comparison of Logistics Readiness Indicators

	Monthly Means				
Logistics Indicator ‡	**Period 1 8-Hr Shift**	**Period 2 12-Hr Shift**	**Period 3 8-HrShift**	**Difference Between Means**	**Periods Different**
MC Rate	69.14	70.44	66.68	$p < .03$*	all
LaborHrPerFlyHr	22.37	23.83	14.69	$p < .02$*	1 from 2, 3
AWM	21.02	11.74	18.84	non-significant	na
HS Reliability	79.48	39.52	90.28	non-significant	na
12-Hour Fix Rate	56.66	53.58	62.64	non-significant	na

Notes: * Indicates differences are statistically significant, $p < .05$
‡ Effects of Work Force Skill Level controlled for

Mission Capable Rate. This variable was expected to decline as fatigue and stress increased with the length of time on 12-hour shifts (Folkard and Monk, 1979). The analysis failed to support the expected outcome. An improvement in the Mission Capable Rate was noted during the 12-hour shift period. The fleet MC Rate was 1.30% higher in Period Three than in Period One. These findings are consistent with those of Rosa, et al., (1989) and Williamson, et al. (1994), who reported increases in performance during 12-hour shifts. This improvement can most likely be attributed to increased

personnel resources and higher worker satisfaction associated with 12-hour shifts (Folkard and Monk, 1979; Rosa, 1991). This finding is further supported by a 3.76% decline in the MC Rate after the squadron returned to 8-hour shifts. Decreased worker satisfaction and reduced personnel resources during 8-hour shifts appear to have had more influence on performance than the reduced fatigue and stress associated with this shift (Folkard and Monk, 1979).

Direct Labor Hours per Flying Hour. Lewis and Swaim reported that 12-hour shifts resulted in better communication between work shifts. During 12-hour shifts, there are fewer shift turnovers. Additionally, the workers communicate back and forth with each other between shifts, instead of a third shift. This results in better continuity and more efficient work (1986:888). This variable was expected to decrease during 12-hour shifts, mainly due to more efficient maintenance operations. This hypothesis was not supported by the analysis results. A mean increase of 1.46 labor hours per flying hour was noted during 12-hour shifts ($p < .02$). This difference indicates the work force expended more effort, in terms of direct labor hours, in support of a workload that was relatively unchanged. This statistic is computed using the Direct Labor Hour variable described earlier. Recall that during Period Three, significantly fewer direct labor hours were required than either of the other two periods. This effect is also evident in the Labor Hour Per Flying Hour variable. Therefore, analysis of the difference between the Period Two and Period Three means, beyond that already discussed, would add little or no value to these findings.

Awaiting Maintenance Discrepancies. The mean number of AWM discrepancies was expected to decrease during 12-hour shifts. Upon examination of the period means, this trend appeared evident, however the differences between the period means were not statistically significant. In Period One, the mean number of AWM discrepancies per aircraft was 21.02. In Period Two, this figure dropped to 11.74. After 12-hour shifts were stopped, the mean number of AWM discrepancies climbed to 18.84 per aircraft. Closer examination of the source data revealed a data point of 39.40 AWM discrepancies for one month in Period Three. This figure is nearly 50% higher than the highest single data point observed for any other single month in the study. This data point weakened the statistical power of the ANOVA by producing a larger variance in the data. Thus the ANOVA results are probably conservative. Investigation as to the reason for this seemingly anomalous figure did not raise sufficient suspicion to remove the data point from the analysis as an outlier. Therefore, it must be concluded that no statistically significant differences exist between the AWM discrepancy means. However, past Air Force research emphasizes the importance of distinguishing between statistical significance and practical significance (Crew Systems Directorate, 1996:3). The difference between the mean number of AWM discrepancies appears to have practical significance.

Home Station Reliability. This indicator was expected to improve during 12-hour shifts. Home Station Reliability measures the ability of the work force to prepare aircraft in a timely manner to meet the flying schedule. Like AWM discrepancies, it is an indicator of production, and was expected to benefit from increased personnel resources

(Monk, et al., 1996). An upward trend was noted in the mean rate for Period Two. However, after the effects of Work Force Skill Level were accounted for, the difference was not statistically significant. Neither did the trend appear to reverse after the change back to 8-hour shifts. It was concluded that Home Station Reliability did not improve as a result of 12-hour shifts. These findings are consistent with those of Williamson, et al., (1994), who found no added performance benefits during 12-hour shifts among computer operators.

12-Hour Fix Rate. This indicator measures the squadron's ability to return aircraft to mission capable status within 12 hours of the aircraft returning from a mission in non-mission capable status. Due to the increased task complexity associated with this type of maintenance, 12-hour shifts were expected to have a detrimental effect on this indicator (Folkard and Monk, 1979). However, it was expected that there would be some benefit from reduced shift turnover and increased continuity between shifts (Williamson, et al., 1994). While the mean fix rate during 12-hour shifts increased by 10.04%, this difference was not significant after the effects of work force skill level were removed. This finding offers a prime example of how a comparison using test procedures mentioned in the previous chapter could have led to an inaccurate conclusion. Unfortunately, this would have been an approach similar to "eye-balling" the numbers.

Health and Safety Indicators

Table 3 shows the ANOVA results for comparing the differences between the period means of each of the health and safety indicators. There were no significant

differences between on- or off-duty accident rates. Sick call visits were significantly higher during 12-hour shifts than either 8-hour shift period.

Table 3. Comparison of Health and Safety Indicators

Health and Safety Indicator Rates†	Monthly Means Period 1 8-Hr Shift	 Period 2 12-Hr Shift	 Period 3 8-HrShift	Difference Between Means	Periods Different
Sick Call Visits	0.01	0.10	0.04	p < .01*	2 from 1, 3
On-Duty Accidents	0.01	0.01	0.00	non-significant	na
Off-Duty Accidents	0.00	0.00	0.01	non-significant	na

Notes: * Indicates differences are statistically significant, p < .05
† Occurrences per worker per period

Accident Rates. The hypothesis of higher accident rates during 12-hour shifts was not statistically supported in this study. There were no significant differences in mean on- or off-duty accident rates between all three periods. This coincides with the findings of Laundry and Lees, who found no significant differences between accident rates of 8- and 12-hour shifts (1991). It is possible that the 12-hour shifts actually presented a safer work environment. Increased manning on each shift may have reduced instances of workers trying to accomplish tasks alone that would normally be done by more than one worker. Thus, the effects of increased fatigue and stress that was expected to increase accidents among individual workers (Folkard and Monk, 1979) may have been offset by increased teamwork. There were no differences in off-duty accident rates between all three periods. It appears that the increased blocks of time off did not contribute to increased accidents as

suggested by Laundry and Lees (1991). This is plausible, because the Air Force typically has aggressive safety awareness programs in each unit. Training has been associated with reducing negative effects of shiftwork (Crew Systems Directorate, 1996). Finally, it must be noted that the work force was significantly more experienced during Periods Two and Three, than in Period One. This may also help to explain why both on- and off-duty accident rates remained relatively unchanged during 12-hour shifts.

Sick Call Visit Rate. Increased stress and fatigue associated with shiftwork also contribute to poor lifestyle habits such as smoking and over-eating. These factors have been shown to have an adverse effect on worker health (Scott and La Dou, 1990). The mean rate of sick call visits per person was significantly higher during 12-hour shifts than either of the two 8-hour shift periods ($p < .01$). When compared to Period One, this rate increased approximately ten-fold in Period Two. When the squadron returned to 8-hour shifts in Period Three, the sick call visit rate began to decline almost immediately. The mean rate for Period Three was less than half that of Period Two. These findings are consistent with those of Sparks, et al., (1997), Budnick, et al., (1994) and Scott and La Dou (1990). Increased fatigue and stress associated with shiftwork appears to have contributed to the increase in worker health complaints.

V. Recommendations and Conclusions

Summary of Findings

The findings indicate the change from 8- to 12- hour shifts resulted in a slight increase in Mission Capable Rates. However, this benefit appears to have come at the expense of worker health, as evidenced by a ten-fold increase in worker sick call visits to the base hospital. There were no significant differences in Home Station Reliability, 12-Hour Fix Rates or Awaiting Maintenance discrepancies. Additionally, the squadron expended a higher proportion of direct labor hours in support of the flying schedule. On- and off-duty accident rates were compared to examine worker safety. These measures showed no significant differences between 8- and 12-hour shift accident rates.

The 1.30% increase in MC Rate equates to an average increase of 114 mission capable hours per aircraft per year. This figure represents additional capacity. If this additional capacity is needed to fulfill mission requirements, then this improvement has practical significance, as well as statistical significance. However, if this additional aircraft availability represents excess capacity, then the increased MC Rate has little practical significance. When operations tempo presents a need for increased capacity, leaders must decide whether or not the increased capacity warrants the adverse impact on the health of the work force.

Limitations and Suggestions for Further Research

This study may not be generalizable to some sectors of commercial industry. Military organizations typically develop a sense of esprit de corps different from that of profit-driven organizations. Additionally, the nature of the work -- maintaining and preparing aircraft for flight -- requires much teamwork. Military aircraft maintenance tasks are often done on short notice and under adverse weather conditions. These challenges may generate increased worker pride or commitment, especially in the face of adversity, and can have a sizeable impact on performance.

The significant increase in sick call visits suggests further research in this area. The physical condition of workers could be measured using data from the Air Force's cycle ergometry program, weight management program and physical health assessments. Questionnaires can be used to measure smoking rates, exercise and eating habits, and how those habits may change during shiftwork. Data from the police blotter could give additional insight about trends in traffic violations, domestic disturbances or other problems. Finally, additional performance and level of effort measures may be helpful in determining additional benefits or detriments of shiftwork.

It would also be very beneficial to examine these same indicators after sufficient time has passed to allow the work force to readjust to an 8-hour shift routine. As mentioned earlier, it would have been ideal to examine the period from October, 1998 through February, 1999. This would yield additional information on the effects of 12-hour shifts by providing the opportunity to see if the indicators returned to their pre-treatment levels.

Finally, this study did not measure two very important factors in determining human performance -- pride and willingness to subordinate one's desires in favor of accomplishing the mission. This large, heavily tasked work force continued to meet mission requirements despite turbulent manpower changes. Additional examination of these factors would contribute greatly to existing research.

Coping with Shiftwork

Twelve-hour shifts are frequently a fact of military life. Reduced manpower levels, high deployment rates and contingency operations often necessitate 12-hour shifts for aircraft maintainers. As leaders, we must give our people every opportunity to make an effective adjustment to their work routine. By doing so, we help protect our most treasured resource, our people.

Rosekind, et al., summarized some significant methods for coping with varying work schedules associated with air transport operations. Some of these mechanisms are equally applicable to support personnel. Workers adapt to shiftwork better when they remain on the same schedule (1993). Needlessly changing a work shift wastes personnel resources in the form of reduced performance and increased health risks.

Maintaining conditions that emulate the daytime environment facilitates worker coping mechanisms. Well-lit work areas help workers adapt more easily to night shifts. Bright light has been found to suppress the release of melatonin -- a hormone that induces sleepiness (Czeisler, et al., 1990). Longer work shifts make it difficult for workers to remain in steady diet and exercise routines. Steady diet and exercise have been shown to

help workers adapt to shiftwork quicker and more easily (Monk et. al., 1996; Ferrer, et al., 1995). Providing and encouraging routine exercise and meal times helps workers maintain a healthy life style. Finally, supervisors can help alleviate shiftwork's negative effects by educating their workers on these coping mechanisms. Duchon and Smith reported that the degree to which management stresses safety helps moderate the effects of shiftwork (1993:47).

Overall, the decision to implement 12-hour shifts is dependent upon the tradeoffs between mission requirements and performance, health and safety factors. To reduce the negative effects, researchers suggest careful consideration of the individuals involved, task characteristics, and implementation schemes for shiftwork. Careful management of shiftwork can result in a healthier and safer work force, whose maximum performance is maintained at minimum additional risk. Management should forecast mission requirements as closely as possible, and attempt to determine where manpower shortfalls exist. Placing only the minimum number of workers needed on extended shifts will help the organization reap the benefits of shiftwork, while minimizing the impact to its people.

Additional Reading

This study covers only some of the effects of shiftwork. Campbell (1998) conducted a related study that measured the impact of shiftwork on individual workers. Outcomes including social support, job satisfaction, reenlistment intentions, tension and fatigue were examined. Taken together, these two studies provide a comprehensive view of the effects of shiftwork.

Additionally, Maddox, et al., put together a comprehensive guide specifically focused on human factors in aviation maintenance (1998). This work provides a comprehensive review of pertinent information and vast references to related shiftwork research, and is available on-line.

Appendix A: Concomitant Variable Data

Month	Period	Sorties	Hours Flown	Manpower	Direct Labor Hours	Workforce Skill Level
Oct-94	1	729	3,018	945	42,280	64.02%
Nov-94	1	487	1,891	934	43,044	63.60%
Dec-94	1	509	1,852	921	36,268	63.08%
Jan-95	1	476	1,752	938	45,245	67.16%
Feb-95	1	407	1,511	937	44,842	66.92%
Oct-96	2	527	2,142	702	40,977	76.21%
Nov-96	2	426	1,992	712	38,780	75.28%
Dec-96	2	388	1,654	712	35,985	75.28%
Jan-97	2	382	1,557	710	41,190	75.07%
Feb-97	2	371	1,641	709	53,027	75.04%
Oct-97	3	524	2,397	699	33,333	72.53%
Nov-97	3	463	2,025	679	25,477	72.46%
Dec-97	3	348	1,472	676	25,667	72.04%
Jan-98	3	377	1,475	656	28,532	71.19%
Feb-98	3	499	2,813	641	28,634	70.83%

Appendix B: Logistics Readiness Indicator Data

Month	Period	Avg AWM	MC Rate	HS Reliability	12 Hr Fix Rate	LbrHrPerFlyHr
Oct-94	1	23.40	70.90	83.50	46.67	14.01
Nov-94	1	17.02	71.80	70.00	39.13	22.76
Dec-94	1	26.85	72.60	83.00	72.73	19.58
Jan-95	1	19.48	68.40	82.70	55.56	25.82
Feb-95	1	18.36	62.00	78.20	69.23	29.68
Oct-96	2	10.10	74.00	94.00	61.11	19.13
Nov-96	2	10.95	73.60	90.30	37.21	19.47
Dec-96	2	11.72	67.40	86.10	60.66	21.76
Jan-97	2	12.21	69.10	84.80	58.18	26.45
Feb-97	2	13.73	68.10	92.40	50.75	32.32
Oct-97	3	39.40	66.40	90.00	58.14	13.91
Nov-97	3	13.77	64.10	93.02	58.14	12.58
Dec-97	3	14.00	65.00	85.92	62.16	17.44
Jan-98	3	13.70	70.00	88.64	68.97	19.35
Feb-98	3	13.33	67.90	93.83	65.79	10.18

Appendix C: Health and Safety Indicator Data

Month	Period	On-Duty Accident Rate	Off-Duty Accident Rate	Sick Call Rate
Oct-94	1	0.01	0.00	0.01
Nov-94	1	0.01	0.01	0.01
Dec-94	1	0.00	0.00	0.01
Jan-95	1	0.00	0.01	0.01
Feb-95	1	0.01	0.00	0.03
Oct-96	2	0.00	0.01	0.07
Nov-96	2	0.00	0.00	0.10
Dec-96	2	0.01	0.00	0.09
Jan-97	2	0.01	0.01	0.12
Feb-97	2	0.01	0.00	0.13
Oct-97	3	0.00	0.01	0.14
Nov-97	3	0.00	0.00	0.01
Dec-97	3	0.00	0.00	0.02
Jan-98	3	0.00	0.01	0.02
Feb-98	3	0.00	0.00	0.01

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Vita

Captain Kelly J. Scott is from Rutland, Vermont. He enlisted in the United States Air Force in 1977. Captain Scott graduated from Franklin Pierce College at Rindge, New Hampshire in 1990 with a Bachelor of Science degree in Computers and Management. He received his commission from Officer Training School in 1991. After completion of the Aircraft Maintenance/Munitions Officer Course at Chanute Air Force Base, Captain Scott was reassigned to the 552d Air Control Wing at Tinker AFB, Oklahoma. There he served as Sortie Generation Flight Commander of the 964th Aircraft Maintenance Unit. His next assignment was to Headquarters, NATO Airborne Early Warning Force Command, at SHAPE, Belgium, where he served as executive officer to the Force Commander and as logistics policy and programs staff officer. Following the NATO assignment, he entered the Air Force Institute of Technology at Wright-Patterson AFB, Ohio. Captain Scott graduated in 1998 with a Masters degree in Logistics Management. He was reassigned to the Force Protection C2 Systems Program Office, Electronic Systems Center, AFMC, Hanscom AFB, Massachusetts. Captain Scott and his wife Joann have been married for 19 years. They have two daughters -- Briana, age 14 and Jami, age 11.

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13. ABSTRACT (*Maximum 200 Words*)
This study examined the effects of converting a large USAF aircraft maintenance squadron from an 8-hour shift system to a 12-hour shift system. In 1996, the squadron converted its 24-hour operations from three 8-hour work shifts, to two 12-hour work shifts with compressed work weeks. The squadron maintained 12-hour shifts for 19 consecutive months. A comparison was made of organizational performance, worker health and safety measures before, during and after 12-hour shift implementation. Findings indicated that changing from 8- to 12-hour shifts resulted in a slight increase in aircraft Mission Capability rates. However, this benefit appears to have come at the expense of worker health, as evidenced by a ten-fold increase in worker sick-call visits to the base hospital. Additionally, the squadron expended a higher proportion of direct labor hours in support of the flying schedule. There were no significant differences in any other aircraft reliability, maintenance repair or deferred maintenance indicators. On- and off-duty accident rates were also examined. There were no significant differences noted between mean 8- and 12-hour shift accident rates. The decision to implement 12-hour shifts is one that must be made with careful consideration of the costs and benefits identified in this study.

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